

WHAT IS CLAIMED IS:

1. A membrane comprising:
  - (a) a hydrophobic matrix polymer and
  - (b) a hydrophilic non-ionic polymer,

wherein said hydrophobic polymer and said hydrophilic polymer form together a selectively proton-conducting membrane.

2. The membrane of claim 1, wherein said hydrophobic polymer and said hydrophilic polymer are distributed in a substantially homogeneous blend.

3. The membrane of claim 1, wherein said hydrophobic polymer and said hydrophilic polymer organize into at least two phases.

4. The membrane of claim 1, wherein said hydrophobic polymer and said hydrophilic polymer organize into a miscible phase.

5. The membrane of claim 1, wherein said proton-conducting membrane includes at least two non-miscible phases.

6. The membrane of claim 1, wherein said selectively proton-conducting membrane is substantially a barrier to cationic species other than protons.

7. The membrane of claim 1, wherein said selectively proton-conducting membrane is substantially a barrier to anionic species.

8. The membrane of claim 1, wherein said selectively proton-conducting membrane is substantially a barrier to neutral species.

9. The membrane of claim 1, wherein said selectively proton-conducting membrane is substantially a barrier to gaseous species.

10. The membrane of claim 1, wherein said selectively proton-conducting membrane is substantially a barrier to organic species.

11. The membrane of claim 1, wherein said selectively proton-conducting membrane is substantially a barrier to anionic species, neutral species, gaseous species, organic species, and cationic species other than protons.

12. The membrane of claim 1, wherein said selectively proton-conducting membrane is substantially a barrier to water.

13. The membrane of claim 1, wherein said hydrophobic polymer includes a first functional group and wherein said hydrophilic polymer includes a second functional group, said first and second functional groups are configured by an interaction to form a conduit for the selective conduction of protons.

14. The membrane of claim 13, wherein said interaction is selected from the group consisting of H-bonding interactions, electrostatic interactions, pi orbital interactions, dipole-dipole interactions, dipole induced dipole interactions, charge transfer interactions and an interaction representing a sum of a mutual repulsive force between dissimilar segments within one of said polymers and a repulsive source between said polymers.

15. The membrane of claim 13, wherein said first functional group is selected from at least one of the groups consisting of halide, nitro, sulfone, nitrile, ether, carbonyl, benzyl, aromatic, and heterocyclic aromatic groups.

16. The membrane of claim 13, wherein said second functional group is selected from at least one of the groups consisting of amide, lactam, Schiff base, hydroxyl amine, ether, phosphonate, heterocyclic containing a cyclic nitrogen atom, heterocyclic containing a cyclic oxygen atom, and heterocyclic containing a cyclic sulfur atom.

17. The membrane of claim 1, wherein said hydrophobic matrix polymer is a fluoro-polymer selected from the group consisting of polymer, copolymer, and terpolymer.

18. The membrane of claim 1, wherein said hydrophilic polymer has at least one functional group selected from the group consisting of amides, lactams, and amines.

19. The membrane of claim 1, wherein said hydrophobic polymer is selected from the group consisting of polyvinylidene fluoride (PVDF), copolymers thereof, terpolymers thereof, polyphenylene oxide, polysulfone, polyether sulfone, polyphenyl sulfone, combinations thereof, and derivatives thereof.

20. The membrane of claim 1, wherein said hydrophilic polymer is selected from the group consisting of polyvinylpyrrolidone, copolymers of polyvinylpyrrolidone, poly (2-methyl-2-oxazoline) polymers, poly (2-ethyl-2-oxazoline) polymers, combinations thereof, and derivatives thereof.

21. The membrane of claim 1, wherein said hydrophobic polymer is selected from the group consisting of polyvinylidene fluoride and polyvinylidene fluoride co-hexafluoropropylene, and wherein said hydrophilic polymer is selected from the group consisting of polyvinylpyrrolidone and poly(2-ethyl-2-oxazoline).

22. The membrane of claim 1, further comprising:

- (c) a porous support layer for supporting said selectively proton-conducting membrane.

23. The membrane of claim 1, wherein said selectively proton-conducting membrane is free-standing.

24. The membrane of claim 1, wherein said selectively proton-conducting membrane is a single membrane, said single membrane further comprising:

(c) an embedded net.

25. The membrane of claim 1, wherein said selectively proton-conducting membrane is a single membrane, said single membrane further comprising:

(c) a non-woven material.

26. The membrane of claim 1, wherein said selectively proton-conducting membrane is a single membrane, said single membrane further comprising:

(c) a randomly structured material.

27. The membrane of claim 1, wherein said selectively proton-conducting membrane is a layer in a composite membrane having a layer of a cation exchange membrane.

28. The membrane of claim 1, wherein said selectively proton-conducting membrane is a layer in a composite membrane having a layer of an anion exchange membrane.

29. The membrane of claim 27, wherein said composite membrane includes a layer of an anion exchange membrane.

30. A membrane comprising:

- (a) a hydrophobic matrix polymer, and
- (b) a hydrophilic non-ionic polymer,

wherein said hydrophobic polymer and said hydrophilic polymer form together a consolidated selectively proton-conducting membrane.

31. An electrochemical system comprising:

an electrochemical cell including:

- (a) an anode;
- (b) a cathode, and
- (c) a selectively proton-conducting membrane disposed between, and being in communication with, said anode and said cathode, said membrane containing:

- (i) a hydrophobic matrix polymer and
- (ii) a hydrophilic non-ionic polymer.

32. The electrochemical system of claim 31, said anode including at least one material having a metal whose cation can assume at least two different non-zero oxidation numbers, said cathode including a compound forming an electrochemical couple with said anode, and wherein said cell is inherently active in initiation of discharge under ambient conditions.

33. The electrochemical system of claim 31, wherein said anode includes an organic compound that is a source of protons during discharge, and wherein said cathode includes a compound which forms an electrochemical couple with said anode.

34. The electrochemical system according to claim 31, wherein said electrochemical cell is a fuel cell.

35. The electrochemical system according to claim 34, wherein an anodic fuel of said fuel cell is an organic liquid.

36. The electrochemical system according to claim 34, wherein an anodic fuel of said fuel cell is hydrogen.

37. The electrochemical system according to claim 31, wherein said anode forms a first layer, said cathode forms a second layer, and wherein said selectively proton-conducting membrane is structured as a layer in an integrated

assembly, said assembly further including at least one of said first and second layers affixed to said membrane.

38. The electrochemical system according to claim 31, wherein said anode contains a compound of tin.

39. The electrochemical system according to claim 31, wherein said cathode contains a compound of manganese.

40. The electrochemical system according to claim 31, wherein said anode contains a compound of tin, and wherein said cathode contains a compound of manganese.

41. The electrochemical system according to claim 31, wherein said electrochemical cell is a rechargeable battery.

42. The electrochemical system according to claim 41, wherein said rechargeable battery has a thickness of about 0.2 mm to about 8 mm.

43. The electrochemical system according to claim 41, wherein each of said anode and said cathode have a thickness of about 30 microns to about 600 microns.

44. The electrochemical system according to claim 41, wherein said battery is disposed in a smart card.

45. The electrochemical system according to claim 41, wherein said battery is disposed in an RF tag.

46. The electrochemical system according to claim 31, wherein said electrochemical cell is an electrochemical double layer capacitor.

47. The electrochemical system according to claim 46, wherein said double layer capacitor has a plurality of electrodes, and wherein each of said electrodes has a thickness of about 30 microns to about 300 microns.

48. The electrochemical system according to claim 46, wherein said double layer capacitor has a plurality of electrodes, and wherein at least one of said electrodes includes a high surface area carbon material and a protonic medium, said protonic medium selected from the group of materials consisting of water, aqueous acid solutions, sulfonic acids, compounds having at least one alcohol group, and combinations thereof.

49. The electrochemical system according to claim 46, wherein said double layer capacitor has a thickness of about 0.2 mm to about 7 mm.

50. The electrochemical system according to claim 31, wherein said electrochemical cell is a pseudo-capacitor.

51 The electrochemical system according to claim 31, wherein said electrochemical cell is a non-rechargeable battery.

52. The electrochemical system according to claim 41, wherein said hydrophobic matrix polymer is PVDF, and said hydrophilic non-ionic polymer is PVP, and wherein said membrane contains between 57% and 67% PVDF, and between 33% and 43% PVP.

53. The electrochemical system according to claim 41, wherein said hydrophobic matrix polymer is PVDF, and said hydrophilic non-ionic polymer is PVP, and wherein said membrane contains a PVDF to PVP weight ratio of between 1.32 to 1 and 2.03 to 1.

54. The electrochemical system according to claim 41, wherein said hydrophobic matrix polymer is PVDF-HFP, and said hydrophilic non-ionic polymer is PVP, and wherein said membrane contains between 57% and 67% PVDF-HFP, and between 33% and 43% PVP.

55. The electrochemical system according to claim 41, wherein said hydrophobic matrix polymer is PVDF-HFP, and said hydrophilic non-ionic polymer is PVP, and wherein said membrane contains a PVDF-HFP to PVP weight ratio of between 1.32 to 1 and 2.03 to 1.

56. The electrochemical system according to claim 46, wherein said hydrophobic matrix polymer is PVDF, and said hydrophilic non-ionic polymer

is PVP, and wherein said membrane contains between 25% and 33% PVDF, and between 67% and 75% PVP.

57. The electrochemical system according to claim 46, wherein said hydrophobic matrix polymer is PVDF, and said hydrophilic non-ionic polymer is PVP, and wherein said membrane contains a PVDF to PVP weight ratio of between 0.33 to 1 and 0.50 to 1.

58. The electrochemical system according to claim 46, wherein said hydrophobic matrix polymer is PVDF-HFP, and said hydrophilic non-ionic polymer is PVP, and wherein said membrane contains between 25% and 33% PVDF-HFP, and between 67% and 75% PVP.

59. The electrochemical system according to claim 46, wherein said hydrophobic matrix polymer is PVDF-HFP, and said hydrophilic non-ionic polymer is PVP, and wherein said membrane contains a PVDF-HFP to PVP weight ratio of between 0.33 to 1 and 0.50 to 1.

60. A method of operating an electrochemical cell, the method comprising the steps of:

- (a) providing an electrochemical cell including:
  - (i) an anode;
  - (ii) a cathode, and

- (iii) a consolidated selectively proton-conducting membrane disposed between, and being in communication with, said anode and said cathode.
- (b) transporting protons across said membrane, between said anode and said cathode, and
- (c) substantially obstructing at least one species other than protons from passing through said membrane.

61. A method of producing a membrane, comprising the steps of:

- (a) providing:
  - (i) a hydrophobic matrix polymer;
  - (ii) a hydrophilic non-ionic polymer, and
  - (iii) at least one common solvent for said hydrophobic matrix polymer and said hydrophilic non-ionic polymer;
- (b) dissolving in said at least one common solvent, said hydrophobic matrix polymer and said hydrophilic non-ionic polymer, to produce a solution, and
- (c) treating said solution to produce a consolidated selectively proton-conducting membrane.

62. The method of claim 61, wherein said treating includes:

- (i) casting said solution on a substrate.